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**Kita et al.**

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(54) **AIR SPRING**

(71) Applicant: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**, Osaka-shi, Osaka (JP)

(72) Inventors: **Yoshiyuki Kita**, Osaka (JP); **Hirokazu Haraguchi**, Osaka (JP)

(73) Assignee: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**, Osaka-shi, Osaka (JP)

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**F16F 9/0454** (2013.01)

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5/02

USPC ..... 267/122, 121, 35, 64.19, 64.21, 64.23,  
267/64.24, 64.27

See application file for complete search history.

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*Primary Examiner* — Pamela Rodriguez

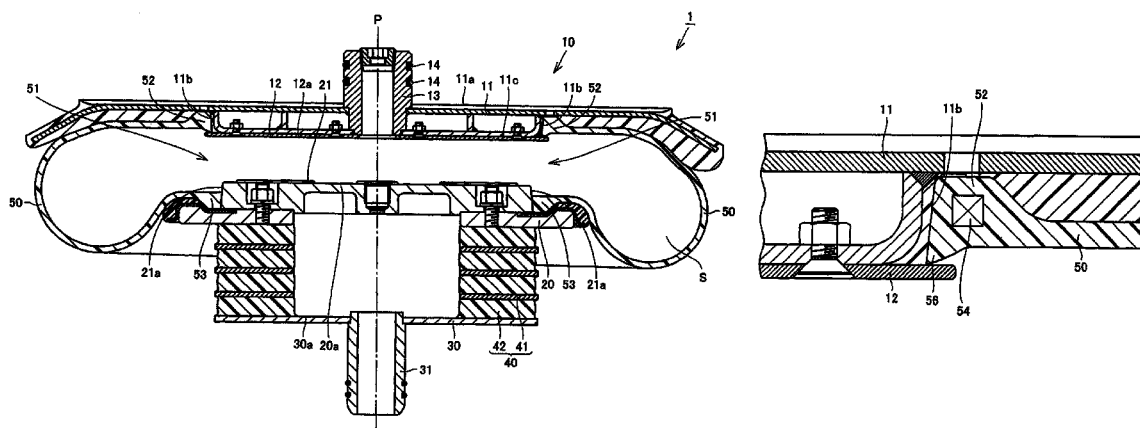
(74) *Attorney, Agent, or Firm* — Drinker Biddle & Reath LLP

(57)

**ABSTRACT**

An air spring includes an upper surface plate, a lower surface plate, and a diaphragm connecting the upper surface plate and the lower surface plate. The diaphragm has an annular shape having an opening on an inner circumferential side. In the diaphragm, an upper surface plate contact portion, which is a region defining the opening and being in contact with the upper surface plate, includes a deformed portion elastically deformed to protrude toward the lower surface plate side by contact with a support plate. The deformed portion is in contact with a sliding member located on the lower surface plate side when viewed from the deformed portion.

**4 Claims, 6 Drawing Sheets**



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(2006.01)

**F16F 9/04**

(2006.01)

(56)

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**FIG. 1**

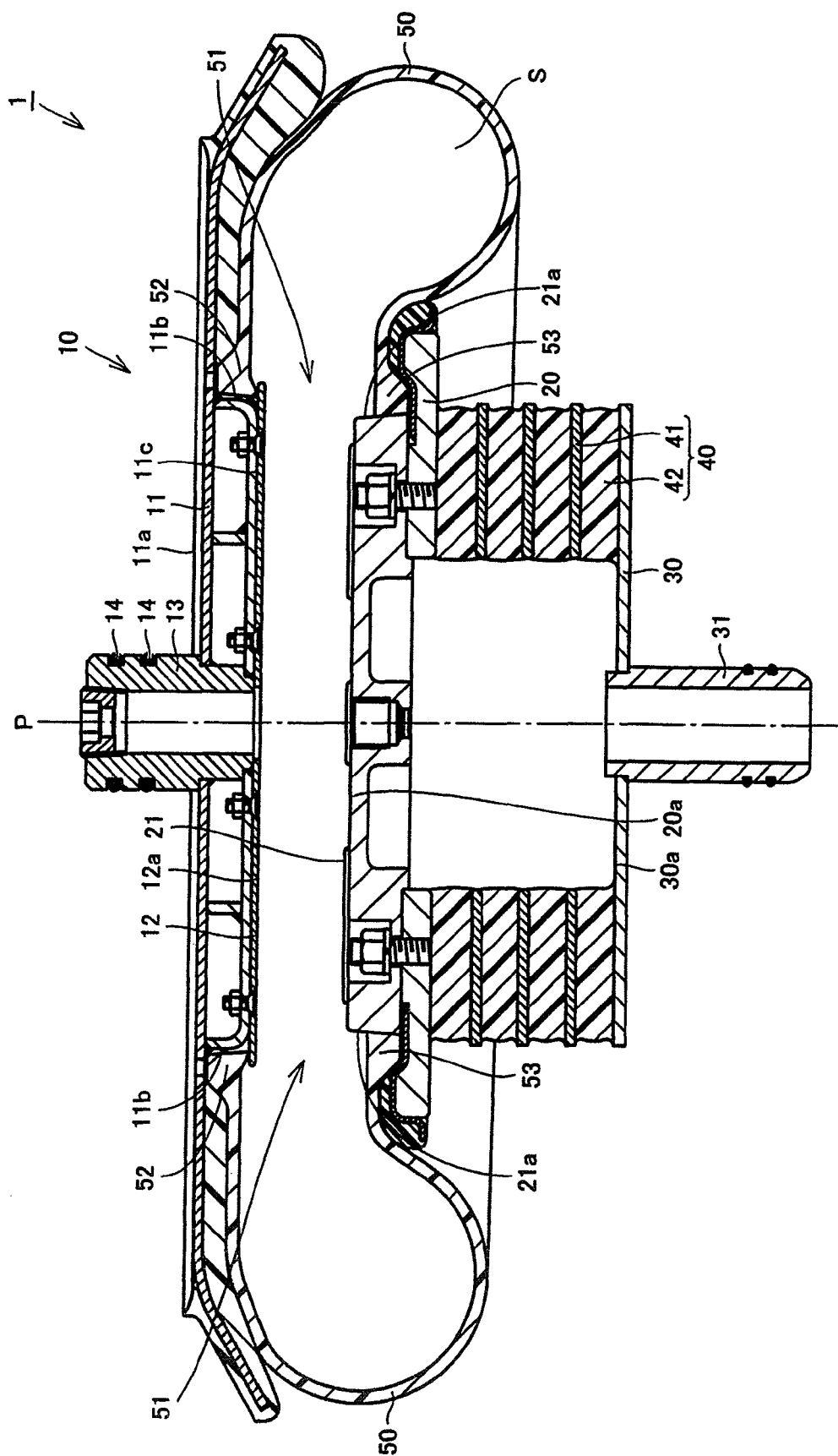


FIG.2

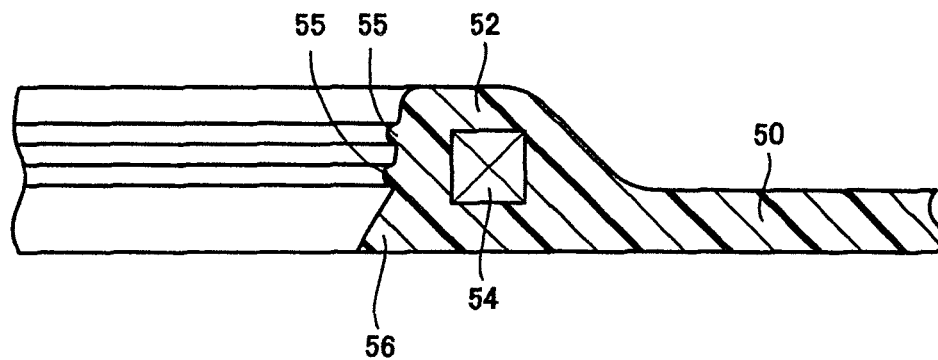
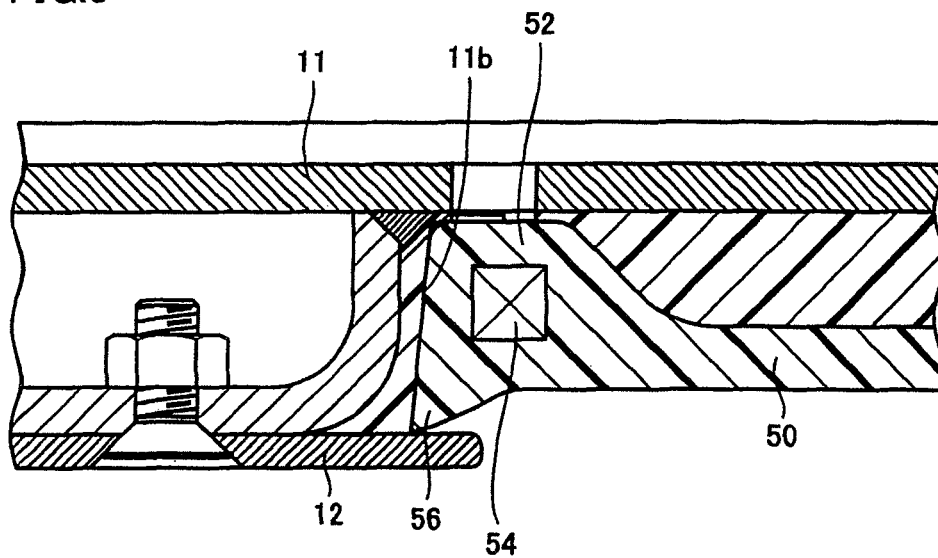


FIG.3



**FIG. 4**

FIG.5

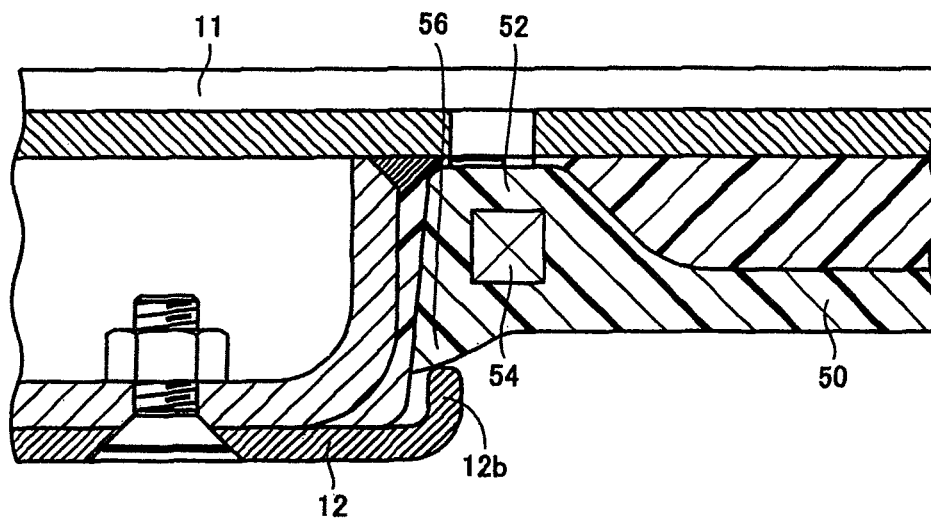
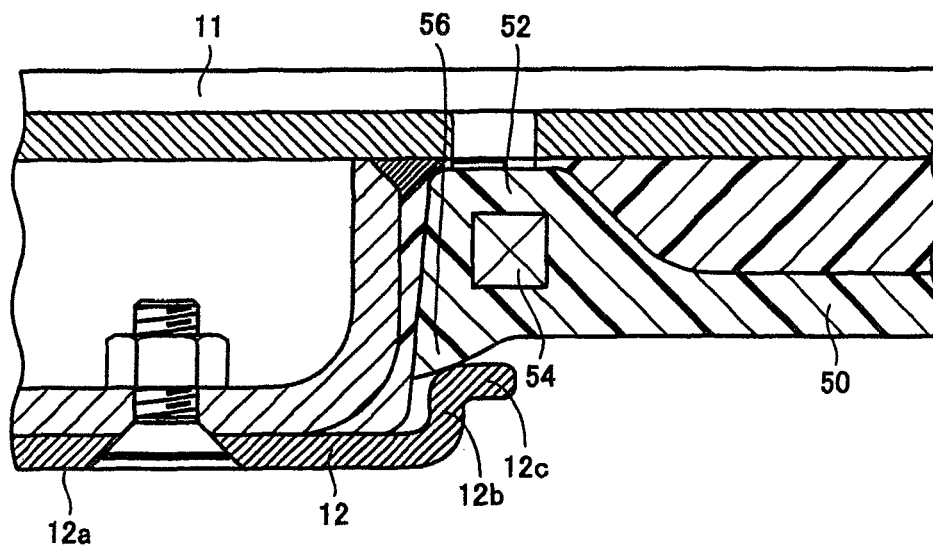


FIG.6



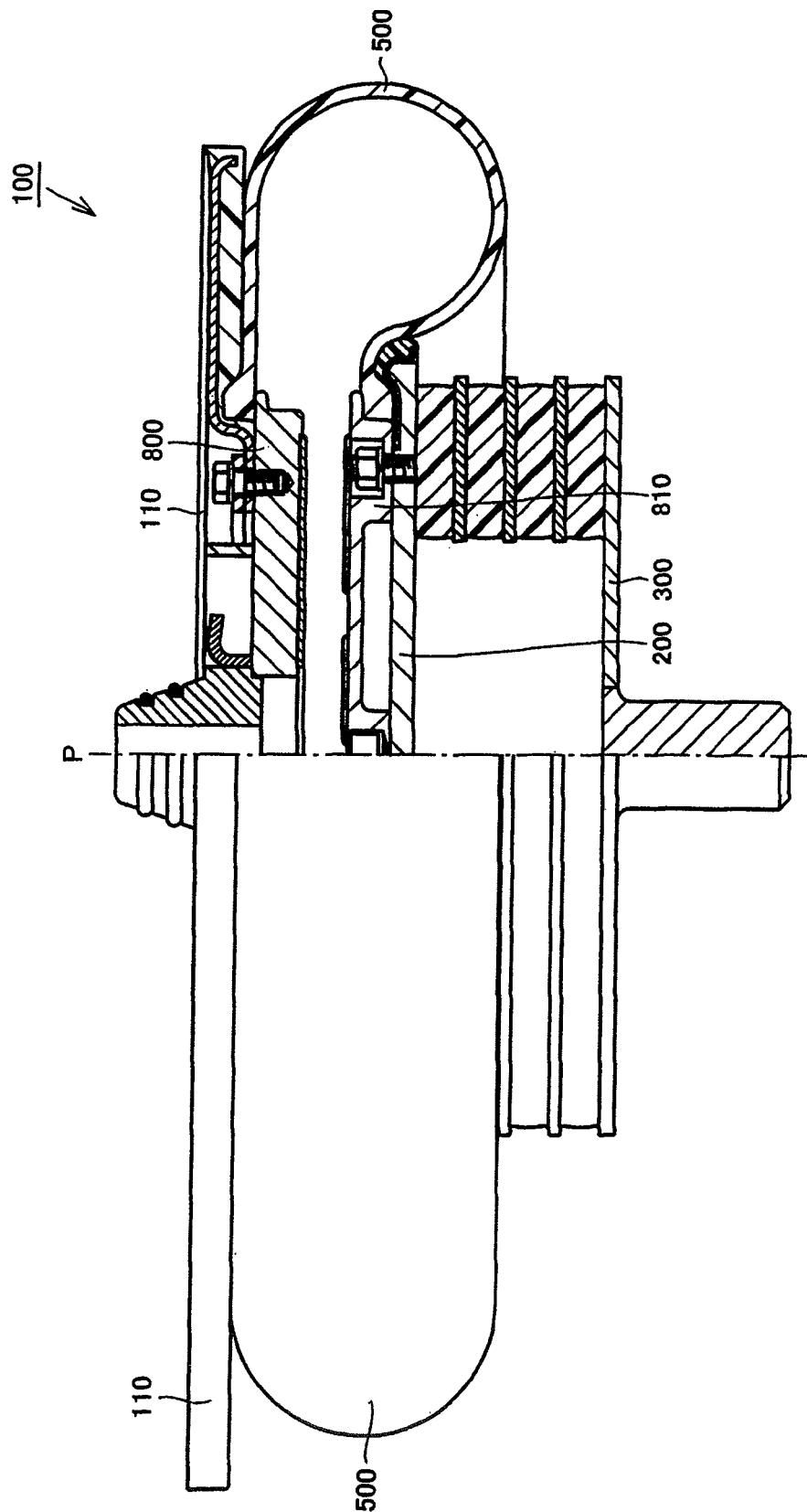


FIG.8 PRIOR ART

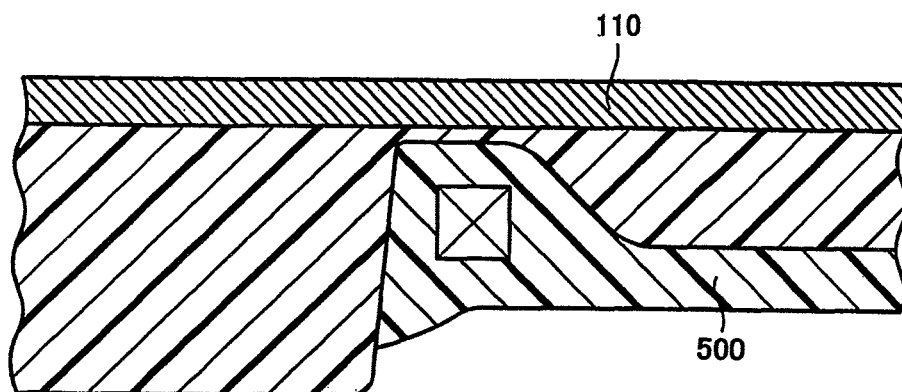
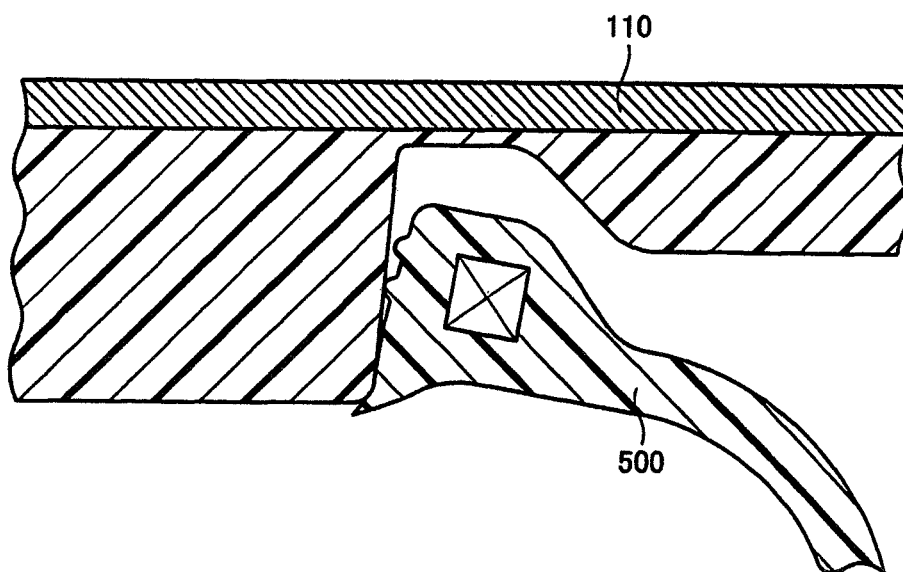


FIG.9 PRIOR ART





## 1

## AIR SPRING

## TECHNICAL FIELD

The present invention relates to an air spring, and more particularly to an air spring that can suppress the increase in its weight and ensure the air tightness of a diaphragm more reliably.

## BACKGROUND ART

In a railroad vehicle, an air spring is arranged between a vehicle main body and a bogie to reduce the impact and vibration applied to the vehicle body while the vehicle is running. The air spring mainly includes an upper surface plate connected to the vehicle main body side, a lower surface plate arranged below the upper surface plate, and a rubber diaphragm arranged to connect the upper surface plate and the lower surface plate, and by elastic deformation of the diaphragm, the air spring can reduce the impact and vibration in the vertical direction during running. Examples of a sealing method for ensuring the air tightness of the diaphragm in the air spring include a fastening sealing method in which the diaphragm is sandwiched between the upper surface plate and one fastening fitting as well as between the lower surface plate and the other fastening fitting, and the diaphragm is fastened by bolts (refer to, for example, Miyamoto, "Illustrated Description of Mechanism of Train-Thorough Elucidation of Commuter Train-", 2nd edition, Toyokuni Printing Co., Ltd., January, 2010, p. 46 (NPD 1)), a self-sealing method in which the diaphragm is fixed to each of the upper surface plate and the lower surface plate by using the inner pressure of the diaphragm (refer to, for example, "Spring Rigging for Railway Rolling Stock JISE 4206", Japanese Industrial Standards Committee, May, 1989, p. 8, 10-12 (NPD 2)), and the like.

## CITATION LIST

## Non Patent Document

- NPD 1: Miyamoto, "Illustrated Description of Mechanism of Train—Thorough Elucidation of Commuter Train-", 2nd edition, Toyokuni Printing Co., Ltd., January, 2010, p. 46  
 NPD 2: "Spring Rigging for Railway Rolling Stock JISE 4206", Japanese Industrial Standards Committee, May, 1989, p. 8, 10-12

## SUMMARY OF INVENTION

## Technical Problem

In the air spring that adopts the fastening sealing method, the fastening fittings excellent in stiffness and strength are used to ensure the air tightness of the diaphragm. These fastening fittings are heavy in weight. Therefore, use of these fastening fittings leads to an increase in overall weight of the air spring, disadvantageously.

In the air spring that adopts the self-sealing method, it is difficult to ensure contact between the diaphragm and the upper surface plate in the case where the external force is applied in the deflated state with low inner pressure of the diaphragm due to vibration during transportation or handling during inspection, in the case where the diaphragm is significantly deformed due to large displacement applied from the horizontal direction while the vehicle is running, or in the other cases. Therefore, the diaphragm falls off from the upper surface plate and air leakage takes place from between the

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diaphragm and the upper surface plate, disadvantageously. There has also been proposed a structure including a projection (hump) on the lower side of a region of the upper surface plate with which the diaphragm is in contact, in order to prevent the falloff of the diaphragm from the upper surface plate. Such structure cannot, however, prevent the air leakage from the diaphragm effectively.

The present invention has been made in light of the aforementioned problem, and an object thereof is to provide an air spring that can suppress the increase in its weight and ensure the air tightness of the diaphragm more reliably.

## Solution to Problem

An air spring according to the present invention includes: a first support member; a second support member spaced apart from the first support member in a primary load direction; and an elastically deformable diaphragm connecting the first support member and the second support member to form a closed space. The diaphragm has an annular shape having an opening on an inner circumferential side. In the diaphragm, a first contact portion, which is a region defining the opening and being in contact with the first support member, includes a deformed portion elastically deformed to protrude toward the second support member side by contact with the first support member. The deformed portion is in contact with the first support member located on the second support member side when viewed from the deformed portion.

In the air spring according to the present invention, the deformed portion of the diaphragm is in contact with the first support member located on the second support member side when viewed from the deformed portion. Therefore, the contact between the diaphragm and the first support member can be ensured reliably at the deformed portion, without using a heavy-weight fastening member and the like to fix the diaphragm to the first support member. As a result, the falloff of the diaphragm from the first support member can be suppressed, and thus, the air leakage from the diaphragm can be prevented. As described above, according to the air spring of the present invention, there can be provided an air spring that can suppress the increase in its weight and ensure the air tightness of the diaphragm more reliably.

In the aforementioned air spring, the deformed portion may be compressed in the primary load direction by contact with the first support member located on the second support member side when viewed from the deformed portion.

As a result, just when the deformed portion of the diaphragm falls off from the first support member, the compressed deformed portion is restored, and thus, the contact between the diaphragm and the first support member can be ensured more reliably. Consequently, the air tightness of the diaphragm can be ensured even more reliably.

In the aforementioned air spring, the first support member may include a first support and a second support arranged on the second support member side when viewed from the first support. The deformed portion may be in contact with the second support.

As a result, the contact between the diaphragm and the first support member is ensured reliably, and attachment and removal of the diaphragm become easier.

In the aforementioned air spring, the second support may be a sliding member. As a result, the impact and vibration applied from outside can be easily lessened. By using the sliding member, an increase in the number of components can be avoided and the air tightness of the diaphragm can be ensured reliably. The sliding member herein refers to a com-

ponent having a reduced surface friction coefficient as compared with the other components of the aforementioned air spring.

In the aforementioned air spring, the second support may have, on an outer circumferential surface, a protruding portion protruding toward a side opposite to the second support member. The deformed portion may be in contact with the second support at the protruding portion. As a result, the diaphragm and the first support member can be brought into contact with each other more easily.

In the aforementioned air spring, the second support member may be arranged below the first support member in the primary load direction. As a result, the structure of the aforementioned air spring can be further simplified.

#### Advantageous Effects of Invention

As is clear from the aforementioned description, according to the air spring of the present invention, there can be provided an air spring that can suppress the increase in its weight and ensure the air tightness of the diaphragm more reliably.

#### BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic view showing a structure of an air spring.

FIG. 2 is a schematic view showing a structure of a diaphragm of the air spring.

FIG. 3 is an enlarged schematic view of the structure of the air spring.

FIG. 4 is a schematic view showing a structure of an air spring according to a modification.

FIG. 5 is an enlarged schematic view showing the structure of the air spring according to the modification.

FIG. 6 is an enlarged schematic view showing the structure of the air spring according to the modification.

FIG. 7 is a schematic view for describing an air spring according to a comparative example.

FIG. 8 is a schematic view for describing an air spring according to a comparative example.

FIG. 9 is a schematic view for describing the air spring according to the comparative example.

#### DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described hereinafter with reference to the drawings, in which the same or corresponding portions are denoted by the same reference numerals and description thereof will not be repeated.

In the beginning, a structure of an air spring according to a comparative example will be described. A structure of an air spring 100 according to one comparative example will be described first. Referring to FIG. 7, in air spring 100, a diaphragm 500 is sandwiched between an upper surface plate 110 and a fastening fitting 800 as well as between a lower surface plate 200 and a fastening fitting 810, and diaphragm 500 is fastened by bolts. In air spring 100, the air tightness of diaphragm 500 is ensured, while it is necessary to use heavy-weight fastening fittings 800 and 810, which leads to an increase in overall weight of the air spring disadvantageously. It is also necessary to apply uniform force to a sealed portion of diaphragm 500 and fasten diaphragm 500 in order to prevent the air leakage, which leads to an increase in the number of components such as bolts. In addition, stress relaxation (creep) occurs in the sealed portion of diaphragm 500, and thus, torque management during fastening is difficult and the assembly work requires a technique.

Next, a structure of an air spring according to another comparative example will be described. Referring to FIG. 8, in this air spring, diaphragm 500 is fixed to upper surface plate 110 by using the inner pressure of diaphragm 500. In this air spring, it is difficult to ensure contact between diaphragm 500 and upper surface plate 110 in the case where the external force is applied in the deflated state with low inner pressure of diaphragm 500 due to vibration during transportation or handling during inspection, in the case where diaphragm 500 is significantly deformed due to large displacement applied from the horizontal direction while the vehicle is running, or in the other cases. Therefore, as shown in FIG. 9, diaphragm 500 falls off from upper surface plate 110 and the air leakage takes place from between diaphragm 500 and upper surface plate 110, disadvantageously. In order to deal with the aforementioned air spring according to the comparative example, an air spring according to the present embodiment is an air spring that can suppress the increase in its weight and ensure the air tightness of the diaphragm more reliably as described below.

A structure of an air spring according to one embodiment of the present invention will be described first. Referring to FIG. 1, an air spring 1 according to the present embodiment mainly includes an upper surface plate 10 serving as a first support member, a lower surface plate 20 serving as a second support member, a rubber lower plate 30, a stacked rubber 40, and a diaphragm 50.

Upper surface plate 10 mainly has a support plate 11 serving as a first support, and a sliding member 12 serving as a second support. Support plate 11 has, for example, a circular shape centered at an axis line (central axis) P, when viewed from above an upper surface 11a. In a central portion including axis line P, support plate 11 is provided with a circular-platform-shaped protruding portion protruding toward the lower surface plate 20 side, and an outer circumferential surface of the protruding portion is provided with a circumferential surface 11b along axis line P. Circumferential surface 11b is formed to be substantially parallel to axis line P.

Sliding member 12 is arranged on the lower surface plate 20 side when viewed from support plate 11. More specifically, sliding member 12 is fixed to support plate 11 by a bolt on a lower surface 11c of the protruding portion formed on support plate 11. Sliding member 12 includes a region extending more radially outwardly than the protruding portion. A main surface 12a of sliding member 12 that faces lower surface plate 20 is a surface having a reduced friction coefficient.

A vehicle body-side spigot 13 protruding toward the side opposite to the lower surface plate 20 side along axis line P is attached to a region of upper surface plate 10 including axis line P. An O-ring 14 is attached to an outer circumferential portion of vehicle body-side spigot 13. Upper surface plate 10 is connected to the vehicle body side (not shown) via vehicle body-side spigot 13.

The shape of support plate 11 when viewed from above upper surface 11a is not limited to the circular shape, and may be, for example, a rectangular shape, a shape of petals, or such a shape that a part of the outer circumferential portion protrudes radially. In addition, as shown in FIG. 1, support plate 11 has such a shape that, toward the radial outer side, support plate 11 is bent along the outer shape of diaphragm 50 downwardly in the primary load direction when viewed from support plate 11. As a result, damage caused by contact between diaphragm 50 and support plate 11 can be prevented.

Lower surface plate 20 is spaced apart from and arranged below upper surface plate 10 in the primary load direction so as to share axis line P with upper surface plate 10. A sliding

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plate **21** made of, for example, stain less steel is arranged on a main surface **20a** of lower surface plate **20** that faces upper surface plate **10**. Similarly to circumferential surface **11b** of upper surface plate **10**, lower surface plate **20** is provided with a circumferential surface **21a** along axis line P.

Diaphragm **50** connects upper surface plate **10** and lower surface plate **20** to form a closed space. Diaphragm **50** is made of, for example, rubber and is elastically deformable. A structure of diaphragm **50** will be described in detail. Diaphragm **50** has an annular shape centered at axis line P, which has an opening **51** on the inner circumferential side. Diaphragm **50** includes an upper surface plate contact portion **52** and a lower surface plate contact portion **53** serving as a first contact portion that defines opening **51**, and diaphragm **50** is in contact with circumferential surfaces **11b** and **21a** of upper surface plate **10** and lower surface plate **20** at upper surface plate contact portion **52** and lower surface plate contact portion **53**, respectively. As a result, upper surface plate **10**, lower surface plate **20** and diaphragm **50** form a closed space S.

The structure of diaphragm **50** will be described in more detail with reference to FIGS. 2 and 3. First, the structure of diaphragm **50** before diaphragm **50** is incorporated into air spring **1** will be described with reference to FIG. 2. A wire **54** having a circular shape along the circumferential surface of the support plate forming the upper surface plate is embedded in upper surface plate contact portion **52** of diaphragm **50**. Upper surface plate contact portion **52** is provided with a projecting portion **55** and a deformed portion **56** protruding toward the inner circumferential side of diaphragm **50**. Deformed portion **56** is formed such that an inner diameter of diaphragm **50** becomes gradually smaller toward the axial lower side.

Next, the structure of diaphragm **50** incorporated into air spring **1** will be described with reference to FIG. 3. Deformed portion **56** of upper surface plate contact portion **52** is in contact with circumferential surface **11b** to follow circumferential surface **11b** of support plate **11** formed along the axial direction. As a result, deformed portion **56** is elastically deformed to protrude toward the lower surface plate side. Deformed portion **56** elastically deformed as described above is in contact with the upper surface plate (sliding member **12**) located on the lower surface plate side when viewed from deformed portion **56**. At this time, deformed portion **56** may be compressed by the contact with sliding member **12**, and more specifically, may be compressed in the primary load direction.

Referring to FIG. 1, laminated rubber **40** is arranged on the side opposite to upper surface plate **10** when viewed from lower surface plate **20**. Laminated rubber **40** has a plurality of hard layers **41** made of metal or the like as well as a plurality of elastic layers **42** made of rubber or the like, and has such a structure that hard layers **41** and elastic layers **42** are alternately stacked in the primary load direction, for example. Since laminated rubber **40** has the plurality of elastic layers **42**, laminated rubber **40** is elastically deformable. A hollow portion is formed in a region of laminated rubber **40** including axis line P.

Rubber lower plate **30** is arranged under laminated rubber **40** so as to share axis line P with upper surface plate **10** and lower surface plate **20**. A bogie-side spigot **31** protruding toward the side opposite to laminated rubber **40** along axis line P is formed in a region of rubber lower plate **30** near axis line P. In other words, bogie-side spigot **31** as a small-diameter portion protruding with axis line P being the central axis is attached to rubber lower plate **30**. Rubber lower plate **30** is connected to the bogie (not shown) side via bogie-side spigot

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**31**. Air spring **1** supports the vehicle body (not shown) with respect to the bogie (not shown) on a support surface **30a** of rubber lower plate **30**.

As described above, in air spring **1** according to the present embodiment, deformed portion **56** of diaphragm **50** is in contact with upper surface plate **10** (sliding member **12**) located on the lower surface plate **20** side when viewed from deformed portion **56**. Therefore, even in the case where the external force is applied in the deflated state with low inner pressure of diaphragm **50** due to vibration during transportation or handling during inspection, in the case where diaphragm **50** is significantly deformed due to large displacement applied from the horizontal direction while the vehicle is running, or in the other cases, for example, the contact between diaphragm **50** and upper surface plate **10** can be ensured reliably at deformed portion **56**, without using a heavy-weight fastening member and the like to fix diaphragm **50** to upper surface plate **10**. As a result, the falloff of diaphragm **50** from upper surface plate **10** can be suppressed, and thus, the air leakage from diaphragm **50** can be prevented. In addition, the structure itself of the air spring is further simplified as compared with the case of using the fastening member. Thus, air spring **1** according to the present embodiment is an air spring that can suppress the increase in its weight and ensure the air tightness of diaphragm **50** more reliably.

In addition, in air spring **1**, deformed portion **56** of diaphragm **50** may be compressed in the primary load direction by the contact with upper surface plate **10** (sliding member **12**) located on the lower surface plate **20** side when viewed from deformed portion **56**, as described above. As a result, just when diaphragm **50** falls off from upper surface plate **10**, compressed deformed portion **56** is restored, and thus, the contact between diaphragm **50** and upper surface plate **10** can be ensured more reliably. Consequently, the air tightness of diaphragm **50** can be ensured more reliably.

In addition, in air spring **1**, upper surface plate **10** may include support plate **11** and sliding member **12** arranged on the lower surface plate **20** side when viewed from support plate **11**, as described above. Deformed portion **56** of diaphragm **50** may be in contact with sliding member **12**. As a result, the contact between diaphragm **50** and upper surface plate **10** can be ensured reliably, and attachment and removal of diaphragm **50** become easier. In other words, in air spring **1**, simply by radially extending sliding member **12** required to lessen the impact and vibration from outside, an increase in the number of components can be avoided and the contact between sliding member **12** and diaphragm **50** can be ensured reliably. In addition, sliding member **12** can be attached to support plate **11** after fixing diaphragm **50** to support plate **11**. Therefore, even when an outer diameter of sliding member **12** is increased to ensure sufficient contact between diaphragm **50** and sliding member **12**, diaphragm **50** can be easily attached during assembly of air spring **1**. In addition, by removing sliding member **12**, the operation for removing diaphragm **50** can also be easily performed.

Next, an air spring according to a modification of the present embodiment will be described. An air spring **2** according to the present modification has a configuration basically similar to that of air spring **1** according to the present embodiment described above, and produces the similar effect. Air spring **2** according to the present modification is, however, different from air spring **1** according to the present embodiment described above, in terms of a structure of the sliding member included in the upper surface plate.

Referring to FIG. 4, in air spring **2**, sliding member **12** included in upper surface plate **10** has, on the outer circum-

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ferential surface, a protruding portion **12b** protruding toward the side opposite to the lower surface plate **20** side. Referring to FIG. 5, deformed portion **56** of diaphragm **50** is in contact with sliding member **12** at protruding portion **12b**. Referring to FIG. 6, protruding portion **12b** has a bent portion **12c** bent along main surface **12a** of sliding member **12**, and deformed portion **56** may be in contact with sliding member **12** at this bent portion **12c**. In air spring **2** according to the present modification, by using sliding member **12** having the aforementioned structure, diaphragm **50** and upper surface plate **10** can be brought into contact with each other more easily.

Although the case of using upper surface plate **10** as the first support member and lower surface plate **20** as the second support member has been described in air springs **1** and **2** according to the present embodiment and the present modification described above, the air spring according to the present invention is not limited thereto. In other words, in the air spring according to the present invention, lower surface plate **20** may be used as the first support member and upper surface plate **10** may be used as the second support member. In this case, there is obtained a structure in which lower surface plate contact portion **53** serving as the first contact portion includes a deformed portion elastically deformed to protrude toward the upper surface plate **10** side by contact with lower surface plate **20**, and this deformed portion is in contact with lower surface plate **20** located on the upper surface plate **10** side when viewed from the deformed portion. As a result, falloff of diaphragm **50** from lower surface plate **20** can be suppressed, and thus, air leakage from diaphragm **50** can be prevented. Consequently, similarly to air springs **1** and **2** according to the present embodiment and the present modification described above, the increase in weight can be suppressed and the air tightness of diaphragm **50** can be ensured more reliably.

It should be understood that the embodiments disclosed herein are illustrative and not limitative in any respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

#### INDUSTRIAL APPLICABILITY

The air spring according to the present invention is particularly advantageously applicable to an air spring that is required to suppress the increase in its weight and ensure the air tightness of the diaphragm reliably.

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#### REFERENCE SIGNS LIST

**1, 2** air spring; **10** upper surface plate; **11** support plate; **11a** upper surface; **11b, 21a** circumferential surface; **11c** lower surface; **12** sliding member; **12a, 20a** main surface; **12b** protruding portion; **12c** bent portion; **13** vehicle body-side spigot; **14** O-ring; **20** lower surface plate; **21** sliding plate; **30** rubber lower plate; **30a** support surface; **31** bogie-side spigot; **40** laminated rubber; **41** hard layer; **42** elastic layer; **50** diaphragm; **51** opening; **52** upper surface plate contact portion; **53** lower surface plate contact portion; **54** wire; **55** projecting portion; **56** deformed portion; P axis line; S closed space.

The invention claimed is:

**1.** An air spring, comprising:

a first support member;

a second support member spaced apart from said first support member in a primary load direction; and  
an elastically deformable diaphragm connecting said first support member and said second support member to form a closed space, wherein

said diaphragm has an annular shape having an opening on an inner circumferential side,

in said diaphragm, a first contact portion, which is a region defining said opening and being in contact with said first support member, includes a deformed portion elastically deformed to protrude toward said second support member side by contact with said first support member,

said deformed portion is in contact with said first support member located on said second support member side when viewed from said deformed portion,

the first support member includes a first support and a second support arranged on the second support member side when viewed from said first support,

the deformed portion is compressed in the primary load direction by contact with the second support, and

the second support is in contact with an underside of the deformed portion.

**2.** The air spring according to claim **1**, wherein said second support is a sliding member.

**3.** The air spring according to claim **1**, wherein said second support has, on an outer circumferential surface, a protruding portion protruding toward a side opposite to said second support member side, and said deformed portion is in contact with said second support at said protruding portion.

**4.** The air spring according to claim **1**, wherein said second support member is arranged below said first support member in said primary load direction.

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